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APRIL 28, 1986

CHEMICAL & ENGINEERING NEWS

Scientific news from the New York ACS meeting

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Aerosols

Back on the road to success
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CHEMICAL & ENGINEERING
NEWS

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News of the Week

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■ **Long-term exposure to TCDD may lead to depression of parts of the immune system.** **Page 5**

■ **EC Commission fines 15 makers of polypropylene for price fixing, market-sharing cartel.** **Page 6**

■ **European Vinyl Corp. formed by Enichem and ICI to make vinyl and polyvinyl chloride.** **Page 6**

Cover: Aerosol cans of Wellcome Foundation's insecticide being produced at Metal Box plant in Sutton-in-Ashfield, England

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News Focus

Chemical community leaders discuss changes in industry, R&D, and education at both ACS and AIChE meetings. **Page 7**

Business

Output of sulfuric and phosphoric acids will be down about 5% this year because of global decline in fertilizer demand; polyethylene supply and demand will stay in balance during 1980s; amorphous polypropylene outlook seems bright. **Page 12**

Government

EPA plans national survey of homes to determine average levels of radon gas and pinpoint areas with especially high levels. **Page 19**

Technology

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Science

From the New York meeting: thyroid disorders and resorcinol; programs for mainframe computers adapted to microcomputer. **Page 66**

ACS News

ACS national meeting in New York—in pictures; U.S. chemists are mostly male, white, and work in industry, survey shows. **Page 70**

Product Report

After a setback by the ban on chlorofluorocarbons, the aerosol industry is on the upswing again, especially in the U.K., Western Europe. **Page 29**

Major Mineral Acids Face Declining Demand

Production of sulfuric and phosphoric acids will drop this year because of lower global consumption of U.S. phosphate fertilizers

Bruce F. Greek, C&EN Houston

Domestic and export demand for phosphate fertilizers in 1986 will be weak, bringing a decline to production of sulfuric and phosphoric acids, the two largest-volume mineral acids. Output of the two acids will be down about 5%, dragging down with it plant operating rates. Major producers and users of those acids, mostly in the fertilizer industry, are debating whether a reversal of the declines will occur next year or later in the 1980s.

Even if output of the acids falls after 1986, plant operating rates might increase. A large amount of capacity to make either sulfuric or phosphoric acids is not operating and might be scrapped later. How much will be scrapped is uncertain. Undoubtedly, economics will be the key to operating old, inefficient plants in competition with new plants.

Moreover, operable capacity to make sulfuric acid from smelters (considered to be a by-product) and from direct manufacture seems to be threatened by the excess capacity and resulting weak prices. More than 5 million tons of 100% H_2SO_4 capacity is available at smelters even after the large amounts of capacity scrapped earlier in this decade. How much of the smelter capacity will be operating by 1990 is uncertain, but industry sources speculate that half of it will be shut down permanently.

A similar, but smaller, overcapacity exists for phosphoric acid. Changes in the overcapacity and operating ratio of plants, however, have been, and are likely to be, more radical than those for sulfuric acid capacity. The situation stems partially from the necessary differences in operating conditions between the two kinds of plants. But a more important factor is the volatility of markets. For example, weather this spring in the major Midwest farming states has been poor, slowing the start of the growing season and reducing the time for application (and hence the quantity) of fertilizer to be used before planting.

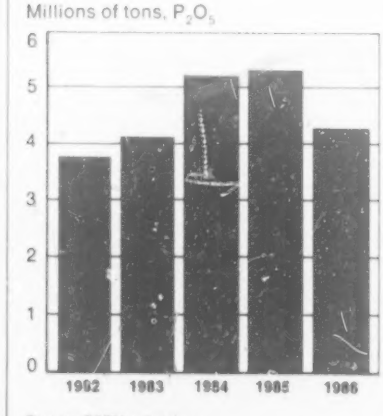
Producers of phosphate fertilizers are hoping for a good fall season as well as improved exports of product later this year to help the start of the 1986–87 fertilizer year. They now are not expected to build much inventory to meet that demand. More inventory will be needed, however, by early 1987 to meet an expected improved demand.

Erratic export demand for phosphate fertilizers adds to the volatility of phosphoric acid plant operations. Exports were strong in the first nine months of 1985, but excessive inventories built up in buying countries, which reduced export demand late in the year. Slow exports of phosphates continued through early 1986, ending plans for increased production during the first half of the year. If a good U.S. fall fertilization season occurs, and if export demand rises strongly during the second half of 1986, inventories will be greatly reduced. Thus it's possible that the phosphate fertilizer industry and phosphoric and sulfuric acid producers could have a better business year in 1987 than they expect to have in 1986.

For details of the near-term outlook for sulfuric and phosphoric acids, please see the following pages.

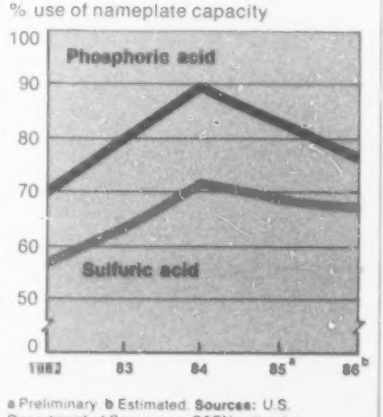
Key Chemicals

Phospnate exports will fall this year



Source: C&EN estimates

Capacity use slips for major mineral acids



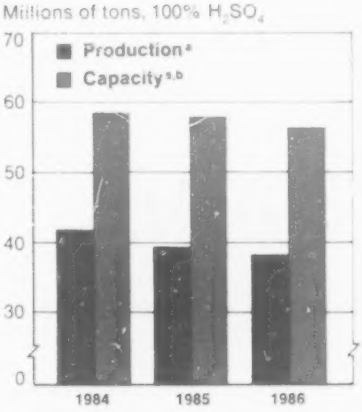
a Preliminary b Estimated. Sources: U.S. Department of Commerce, C&EN estimates

H_2SO_4

Sulfuric acid

- ***Production to decline***
- ***Capacity down more***
- ***Prices low and holding***

PRODUCTION/CAPACITY



a From all sources. b First quarter

MAJOR PRODUCERS

Allied-Signal, American Cyanamid, C-I-L, Du Pont, Stauffer Chemical (Chesebrough-Pond's)

HOW MADE

Sulfur dioxide obtained by burning sulfur or recovered from smelting is oxidized, reacted with water

MAJOR DERIVATIVES

None more than 5% of production

MAJOR END USES

Phosphate and other fertilizer manufacturing 70%, metals production and processing 10%

FOREIGN TRADE

Exports—holding at about 150,000 tons per year, imports—holding at about 500,000 tons per year

PRICES

List for smelter acid, $20 to $50 per ton; for virgin acid, $55 to $95 per ton

Production of sulfuric acid in 1986 will be down again because of a sizable decline in exports of diammonium phosphate (DAP) and lower U.S. farm consumption of phosphate fertilizers—both of which depend on sulfuric acid in their manufacture. Output of the acid will drop 3.5% from last year, following a decline of more than 5% in 1985. Total capacity to make sulfuric acid also declined last year as a result of acid plant closures at several copper ore smelters and at other sites.

In 1986, output of sulfuric acid on a 100% H_2SO_4 basis will total about 38.2 million tons, down from the preliminary estimate of 39.6 million tons in 1985 and down from 41.8 million tons in 1984. Production of the acid peaked in 1980 at nearly 44 million tons.

Capacity dropped relatively steeply in 1985, with an estimated net decline of 1.5 million tons, three times the drop in 1984. Not all of the remaining 56 million tons of capacity is operating. Some plants may never operate again.

Estimates of 1986 output are based on some assumptions that could prove to be incorrect. One assumption is that U.S. use of phosphate fertilizers this spring will come within 95% of use last spring, despite large acreages of farmland left unplanted. Another is that the fall application will be better than it has been in the past two fall seasons, when use of phosphate fertilizers declined about 20% each season.

Outside the fertilizer industry, sulfuric acid demand will be essentially the same as last year. The metals processing industries (such as steel making) likely will hold present levels of production. Chemicals, paper and pulp, and petroleum refining presumably are industries that will consume at least the same amount of sulfuric acid in 1986 as they did last year.

Without those demand conditions, sulfuric acid production this year could fall below the projected 38.2 million tons. The lowest estimate likely would be 1 million tons less, resulting possibly from a larger slump in phosphate fertilizer use and less sulfuric acid consumed in nonfertilizer industries.

The phosphate fertilizer industry continues to be the key to demand for sulfuric acid. Phosphoric acid manufacture consumes more than 70% of sulfuric acid production, most of which is produced captively with energy from the burning of the sulfur recovered as efficiently as possible to improve the overall plant production economics. A large part of this phosphoric acid is exported, and another even larger part is made into ammonium phosphates, mostly DAP, of which a significant quantity goes to exports. Because the DAP market is so large, this single material appears to control the fortunes of sulfuric acid.

Because some past major buyers of DAP—India and China—have bought none in the first quarter and seem unlikely to buy more than a small quantity in the second quarter, 1986 exports of DAP are expected to decline substantially. The decline in DAP exports, plus lower use of fertilizers in the U.S. in 1986, will reduce wet phosphoric acid production to 9.5 million tons of P_2O_5.

The many uses of sulfuric acid outside the fertilizer industry generally are not going anywhere. The increased use of sulfuric acid to leach copper from certain ores and mine tailings is a bright spot. Leaching technology for copper helps the sulfuric acid market because it is a growing use and because it removes from the market acid that must be sold and therefore is priced low. Copper demand and prices have been weak, putting pressure on copper producers to cut costs by an increased use of leaching, which generally lowers costs. However, if copper demand rises, closed smelters could be restarted. And if sulfur dioxide controls required for those smelters' future operation are installed, increased smelter sulfuric acid could be produced, which would end the short-term prop for the sulfuric acid market.

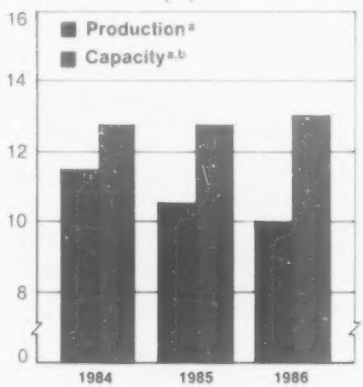
H_3PO_4

Phosphoric acid

- ***Production down again***
- ***Capacity up slightly***
- ***Prices holding***

PRODUCTION/CAPACITY

Millions of tons, P_2O_5



a Wet process and furnace acids. b First quarter

MAJOR PRODUCERS

CF Industries, Freeport Chemical, Occidental Chemical, Texasgulf Chemicals, Williams Cos.

HOW MADE

Reaction of phosphate rock and sulfuric acid; burning of elemental phosphorus and subsequent reaction with water

MAJOR DERIVATIVES

Ammonium phosphates 60%, triple superphosphate 15%

MAJOR END USES

Fertilizers 85%, detergent materials 5%

FOREIGN TRADE

Exports—(as the acid) continuing strong at more than 1 million tons of P_2O_5, imports—remaining small at less than 25,000 tons of P_2O_5

PRICE

List about $300 per ton of P_2O_5

Lower worldwide demand for U.S. phosphate fertilizers will knock down U.S. production of phosphoric acid 5% or more in 1986. Both domestic and export demand for phosphate fertilizers will be down this year. Other uses of phosphoric acid—including that made from electric furnace-produced elemental phosphorus—will do no better than hold even, based on early forecasts.

If major foreign buyers of U.S.-produced fertilizers return to the market strongly in the second half of 1986, production this year could total 10 million tons of phosphoric acid as P_2O_5. That would be down 5% from the 10.5 million tons estimated to have been produced in 1985 and down more than 12% from the 11.4 million tons produced in 1984. If the major importers of such products as diammonium phosphate (DAP)—India and China—do not return to their 1985 buying level, then phosphoric acid production will decline to below 10 million tons as P_2O_5.

Capacity to make wet-process phosphoric acid by reacting sulfuric acid with phosphate rock slowly inched up in 1985 to about 12.4 million tons of P_2O_5. An additional 600,000 tons of capacity is based on burning of elemental phosphorus, and the product is called furnace acid. If some 9.5 million tons of wet-process acid are produced in 1986, the plant capacity available as the year began will run at an average rate of nearly 77%. Furnace acid operating rates will be somewhat higher.

The major additions to wet-process phosphoric acid capacity during 1985 were about 250,000 tons of P_2O_5 by Texasgulf Chemicals and less than 100,000 tons by J. R. Simplot. No significant additions to furnace acid capacity occurred last year. By the end of 1986, Monsanto will end its production of elemental phosphorus in Tennessee, but whether its furnace acid production will be reduced is uncertain.

Most furnace phosphoric acid goes into such end uses as detergent components (tripolyphosphates), foods and beverages, metal treating, and many small uses. As a group, uses of furnace acid are declining because of slowly tightening limits on use of detergent phosphates and changes in consumer product formulations. During 1986, that decline will account for part of the lower production total for phosphoric acid.

About 95% of wet-process phosphoric acid goes into fertilizers of one kind or another. The other 5% goes mostly into animal feed supplements, with a tiny amount being made into sodium tripolyphosphate for detergents. In 1985, more than 9.2 million tons of phosphoric acid as P_2O_5 went to fertilizers, either in the U.S. or in foreign countries. Sources indicate that more than 1 million tons was exported as either regular (54%) or super (70%) acids for subsequent use in fertilizer plants in other parts of the world, especially in the U.S.S.R.

In the combined domestic and export fertilizer markets, DAP accounts for the largest share of phosphoric acid consumption, at about two thirds of the total. Because phosphoric acid exports are a large fraction of all phosphate materials exports, DAP accounted for about 60% of phosphate exports on a P_2O_5 basis in 1985.

In late 1985, because their inventories were too large, India and China stopped their imports of DAP from the U.S. and have yet to restart on any scale. As a result, industry sources forecast that exports of DAP in 1986 could fall as much as a third, assuming that those two countries and others not now buying much will return to former purchasing levels in the second half of the year. More likely, sources say, exports of DAP will be down less than a third for the year. But the loss in exports will be too great to be offset by a better fall fertilizer season in the U.S., leading to the estimated 5% decline in phosphoric acid production for all of 1986.

Polyethylene supply and demand to remain in balance

A lot of polyethylene capacity came on stream throughout the world last year. And much more is scheduled to come on stream each year for the remainder of the decade.

But don't think the world will be wallowing in excess polyethylene capacity. "Overall, I expect capacity and demand will remain in close balance," says David M. Cheek, polyethylene marketing manager in Dow Chemical's olefin and styrenic plastics department. He outlined his worldwide polyethylene projections for the Chemical Marketing & Economics Division.

Last year, about 3.5 billion lb of polyethylene capacity was added to the world supply stream. That, says Cheek, is a lot of polyethylene. Equally important, much of that capacity was built in regions that had been strong markets for U.S. polyethylene over the years.

The leader by far was the Middle East and Africa, where more than 1 billion lb of polyethylene capacity started up last year. Most of it (82%) was low-density polyethylene (LDPE) and linear low-density polyethylene (LLDPE). Canada chipped in with 640 million lb of new polyethylene capacity, with about 62% of it earmarked for LDPE and LLDPE.

The only area to lose polyethylene capacity last year was Japan. As part of an industrywide rationalization program, producers there scrapped 356 million lb of HDPE capacity. That shutdown more than offset the 148 million lb gain in LDPE and LLDPE capacity.

Before the end of the 1980s, Cheek expects an additional 4.7 billion lb of polyethylene capacity to start up throughout the world, most of it planned for this year and 1987. Counting the plants that began operating last year, polyethylene producers will move into the 1990s with an additional 7.8 billion lb of polyethylene capacity.

Some of this new capacity, of course, will replace existing plants, which either are or will become obsolete and unprofitable. But Cheek expects that most of it will become available to meet new worldwide demand. That prospect doesn't particularly bother him, however, because he sees demand growing in lockstep with the buildup in polyethylene capacity.

Cheek estimates that global polyethylene consumption last year was 47.7 billion lb, up 3.9% over 1984. If polyethylene demand maintains that 3.9% average annual growth for the rest of the decade, it will reach a hefty 57.8 billion lb by 1990.

Not all polyethylene growth will be equal, however. Cheek pegs the average annual growth of HDPE at 6.5%, but the combined growth of LDPE and LLDPE at only 2.5%. At those rates, 1990 consumption of LDPE and LLDPE will be 36.1 billion lb, and that of HDPE will hit 21.7 billion lb. Thus, HDPE's share of the total polyethylene market will increase to 37.5% in 1990 from last year's 33%.

"We're dealing with large-volume materials serving huge markets," says Cheek. Despite this, polyethylene is not a typical commodity product. Instead, he explains, marketers are dealing with dozens of differentiated products. Because of its size, the polyethylene market is considered mature. But Cheek thinks that it is also vigorous, with new products appearing frequently, each showing strong signs of continuing growth in sizable volumes.

Sizable volume is the key. When Cheek equates planned expansions in polyethylene capacity with average annual growth in consumption, the 7.8 billion lb of capacity being added during the second half of the 1980s turns out to be less than the demand increases projected for the period. For instance, the 3.5 billion lb of polyethylene capacity that started up last year represents only about two years of projected demand growth for LDPE and LLDPE; less than a year of demand growth for HDPE. The numbers get smaller—much smaller—as the 1980s wear on.

But that doesn't necessarily spell polyethylene shortages, either. The newer plants probably will be expanded with incremental additions to capacity. And sooner or later, says Cheek, the prospect of shortages will be strong enough to trigger plans and announcements for new polyethylene plants. Those announcements, of course, will depend upon how producers fare with profits, which have been a scarce commodity in the polyethylene business recently. Nevertheless, Cheek sees polyethylene supply and demand remaining in close balance for the rest of the 1980s.

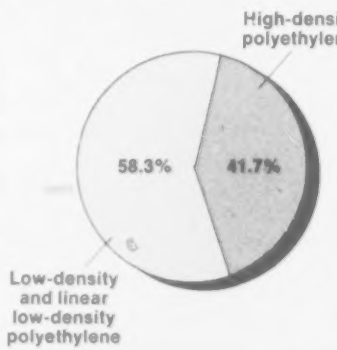
In the U.S., apparent polyethylene consumption (U.S. production

Some 3 billion lb of polyethylene capacity started up last year

Millions of lb	LDPE & LLDPE	HDPE	Total
U.S.	483	180	663
Canada	395	245	640
Western Europe	159	—	159
Eastern Europe	—	176	176
Middle East[a]	838	187	1025
Japan	148	—	148
Far East[b]	55	—	55
Brazil	274	42	316
Latin America[c]	282	—	282
TOTAL	2634	830	3464

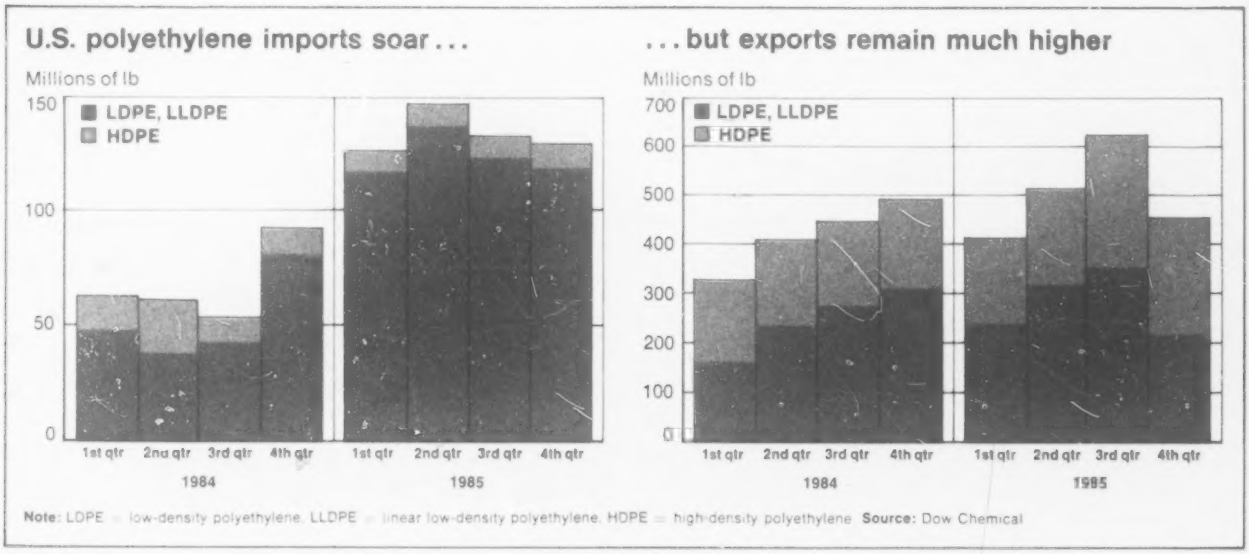
a Includes Africa. b Excludes Japan. c Excludes Brazil.
Source: Dow Chemical

LDPE, LLDPE dominate the polyethylene market



1985 U.S. consumption = 13.9 billion lb

Source: Dow Chemical



Note: LDPE = low-density polyethylene, LLDPE = linear low-density polyethylene, HDPE = high-density polyethylene. **Source:** Dow Chemical

plus imports minus exports) hit 13.9 billion lb. That's a healthy 7.8% jump, almost twice the growth rate of the global average. On a volume basis, LDPE and LLDPE led the way, with 8.1 billion lb of material funneling into the market. But their combined growth rate of 6.6% still trailed that of HDPE, which surged ahead 9.4% to 5.8 billion lb.

Last year's strong increase in U.S. polyethylene consumption is "notable," says Cheek in an obvious understatement. The nearly 8% growth rate far outstrips what most forecasters are pegging for polyethylene's long-term growth—about 2.5 to 3.0% annually. More important, last year had been seen as one in which U.S. production would decline. Sizable new capacity came on stream in Saudi Arabia and Canada during 1984 and 1985. Output from those new plants was expected to appear on U.S. markets as imports. And they were expected to take a lot of business away from U.S. exports in third-country markets.

It didn't happen quite that way. True, polyethylene imports rose—they virtually doubled, from 273 million lb in 1984 to 540 million lb last year. But contrary to predictions, U.S. exports also climbed, rising a healthy 20% to almost 2 billion lb and giving the U.S. a 1.5 billion lb trade surplus in polyethylene. Those exports also helped U.S. polyethylene production to increase an estimated 5.5% last year, rather than decline as expected.

Cheek attributes the gain in exports to a mix of short-term and long-term factors. Plant accidents in Europe, for instance, are one short-term factor. Those accidents deprived some European polyethylene producers of their normal ethylene feedstock supply. That, in turn, created at least a temporary increase in demand for U.S.-produced material to service export markets.

Meanwhile, the impact of new polyethylene production outside the U.S. may take longer to be felt than originally expected. The increases in non-U.S. output were beginning to show up as U.S. imports last year, says Cheek. But he emphasizes "beginning." He believes that it will be some time before the full impact of the new foreign capacity can be measured.

The precipitous drop in crude oil prices, coupled with the sharply lower value of the U.S. dollar, will make U.S. polyethylene producers much more competitive with Middle Eastern producers. What's more, the marketing infrastructure needed to move large volumes of polyethylene from the Middle East still is limited, despite years of preparation. This, says Cheek, will change. But it will take time.

What will not change, however, is a need for conventional LDPE. Over the past few years, LLDPE has become the darling of the polyethylene industry. It is the major growth polymer. Significant gains also are forecast for production and consumption of HDPE.

Where does that leave conventional LDPE? Cheek believes large volumes will be produced and marketed for years to come. There is good evidence, he says, that products made from conventional LDPE can hold their own against LLDPE, based on performance in selected market niches. LDPE will continue to provide value, for instance, as a clarity monolayer film and as a key component in blends for specific applications.

Although demand for all of the polyethylenes will grow over the next few years, and supply will keep pace with it, there's no guarantee that the business will be profitable. If it wants to be profitable, a polyethylene producer must blend together four ingredients, says Cheek.

The first is a competitive raw material position. Cheek thinks that U.S. producers overreacted to the raw material cost position of Saudi Arabia, Canada, and Mexico. In retrospect, he says, U.S. producers are, and will continue to be, competitive, considering the real cost of capital in those areas and the costs needed to establish and maintain an effective infrastructure.

To be successful, producers also need a competitive conversion cost, and a commitment to both technology and marketing. Lack of an effective marketing apparatus probably explains the delayed impact of Saudi polyethylene, says Cheek. □

Amorphous polypropylene prospects look good

Amorphous polypropylene (APP) has gone from the unwanted coproduct of the polypropylene industry to a product that may now be worth producing on purpose.

The situation leaves polypropylene producers in a strategic dilemma. With the new high-yield catalysts now available, one strategy is to use technology that produces virtually all isotactic, or crystalline, polypropylene. The other is to continue finding new, growing uses for APP (atactic).

Last year, Eastman Chemicals division of Eastman Kodak opted for the latter. The company started producing additional volumes of APP in the first phase of a new facility. Newer variations will be available this spring.

But APP wasn't always that attractive, says Jack T. Mahaffey, Eastman's director of market management. In the early stages of the polypropylene industry, all plants produced an amorphous fraction as a by-product or coproduct. The amorphous portion ran from 2 to 15% of the total, depending upon the process and the catalyst.

Today, says Mahaffey, no plants in the U.S. are using 1960s technology. They get more crystalline and less amorphous polypropylene or they use new catalysts that produce no APP at all.

The problem, Mahaffey explained to the Chemical Marketing & Economics Division, was that no market existed for APP. Some companies burned all they produced. Others used it as landfill or dumped it in large pits. With a great deal of effort, a few markets for APP began to develop. It was a pretty good raw material for making adhesives. It could be blended with waxes and petrolatums for cable flooding compounds. And interest developed in APP as a paper laminating adhesive, particularly for kraft papers that were laminated and reinforced with glass fiber filament. Until then, asphalt had been primarily used to laminate papers for lumber overwrap, sealing tapes, furniture wrap, and pipe wrap.

As paper companies switched from asphalt to APP, Mahaffey says, Eastman couldn't make enough APP to keep up with demand. Fortunately, the company still had its pit. Upon restart of mining the pit, the company remelted the APP in the pit, filtered it, cleaned it, and loaded it into tank cars. Other companies did the same thing. Eastman emptied its APP pit in 1984.

Meanwhile, APP consumption in the U.S. has been variously estimated between 130 million and 150 million lb in 1984. That includes imported and recovered materials and Mahaffey estimates that between 10 and 15% of the total was material recovered from the pits. He pegs last year's APP consumption at 126 million lb. But its end-use pattern has changed dramatically. In the 1970s, paper laminating was by far the largest end use, with cable flooding and adhesives next. Now, APP's largest use is as a modifier in asphalt for roofing compounds.

Since it became economically attractive for companies with APP pits to start mining them, the pits have been rapidly depleted.

Considerable amounts of APP are imported, says Mahaffey. But Italy, a historic leader in polypropylene, has essentially depleted all known inventories.

Now, says Mahaffey, the industry has come full circle. It now may pay to produce APP intentionally. In some cases, old polypropylene units may be adapted to manufacture APP. But, because much of the equipment is old, these units may need significant retrofitting.

Today, by-product APP sells for 20 to 25 cents per lb in its dirtiest form and about 40 to 50 cents for the cleanest material. He says that newly made APP will sell for about 42 to 45 cents per lb in molten form and perhaps 5 cents higher as a solid.

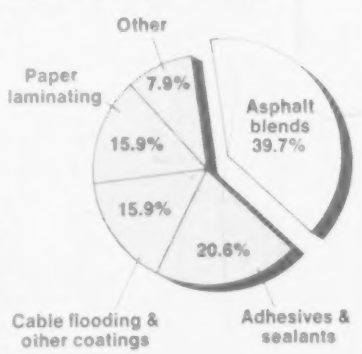
Mahaffey estimates that last year's APP supply in the U.S. was 136 million lb. That includes usable recovered material. He thinks that production of by-product APP may have dropped to a 50 million lb annual rate at the beginning of this year. "There is a mixed bag of reports," he says, on how much is still in the pits in the U.S.

Eastman's APP plant at Longview, Tex., will make only a fond memory of the old pit. It uses a new process that doesn't depend upon the production of crystalline polypropylene as the old processes did. Direct synthesis should help Eastman become a readily available source of APP, says Mahaffey.

But he steadfastly refuses to forecast future demand. There are several ways of looking at it, he says. One is to assume that the markets can't afford the higher price of this APP. If so, producers have no incentive to invest money for on-purpose plants. Demand will equal supply, and alternative materials will be found to accommodate the markets.

However, another possibility is to assume there will be a pretty vigorous growth rate of about 15% annually for the next few years and that customers will pay the higher price. One big unknown is the supply available from European pits. Most pits in the U.S. have been exhausted or are well on their way. But not that much is known about the APP pits in Europe. Thus, supply reliability is a big question mark. □

Asphalt blends take big share of APP market



1985 consumption = 126 million lb

Source: Eastman Chemical Products

Aerosols Back on Road to Success

Aerosol cans produced by Metal Box in Sutton-in-Ashfield, England

Patricia L. Layman, C&EN London

The word is out around the industry: Aerosols are finally recovering from their long battle with adversity. In Western Europe, output growth in the aerosol industry is approaching 9% per year; in the U.K., output in 1985 was 11% higher than in 1984, according to figures just released by the British Aerosol Manufacturers' Association (BAMA). And when U.S. figures are published next month at the spring meeting of the Chemical Specialties Manufacturers Association (CSMA) in Chicago, they are expected to show an increase of 3 to 4% over 1984—the second year of growth in a row.

That, says Sam F. Copia, vice president of marketing for propellant supplier Aeropres Corp., Shreveport, La., means "the American public has given its stamp of approval to aerosols as a packaging form. I doubt whether any other package could have survived the attacks that the media leveled at aerosols," and, in some cases, still levels. "It is the most efficacious package that has been designed," he adds.

This is high praise for a packaging form that has been more accustomed to brickbats over the past decade. In fact, the general posture of the industry has been defensive, low-profile sheltering. But that is changing. From a lack of development in new technology and products, suppliers report they are seeing a rekindled interest in new systems and materials for customers' products.

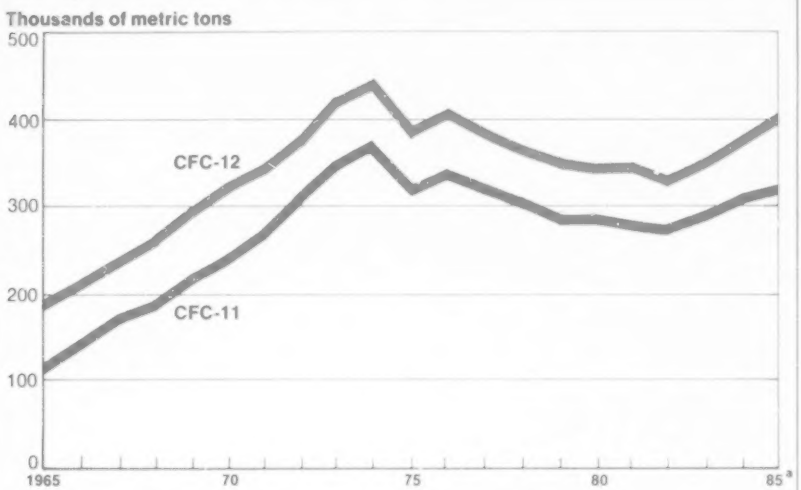
That's good news for the chemical industry. In a sense, the aerosol industry is a strange bird. It views itself as unique. In practice, it is just one more packaging medium. That helps explain the reluctance of marketers to promote aerosols. They want to promote their own products. But, perhaps because the aerosol industry became intertwined so early on with chemical-specialty products, it has always had a strong association with the chemical industry rather than the packaging business.

The aerosol industry is a significant purchaser of chemical products in addition to the contents of the products put into aerosol cans. For example, it consumes some 250 million lb per year of hydrocarbon propellants. Aerosol hair sprays have boosted consumption of ethanol significantly over the past 20 years. The industry sometimes needs high-performance interior can linings. And many of the parts of an aerosol container are plastic, making these packages in turn a good customer of the chemical industry. The improving health of the industry, then, benefits chemicals as well.

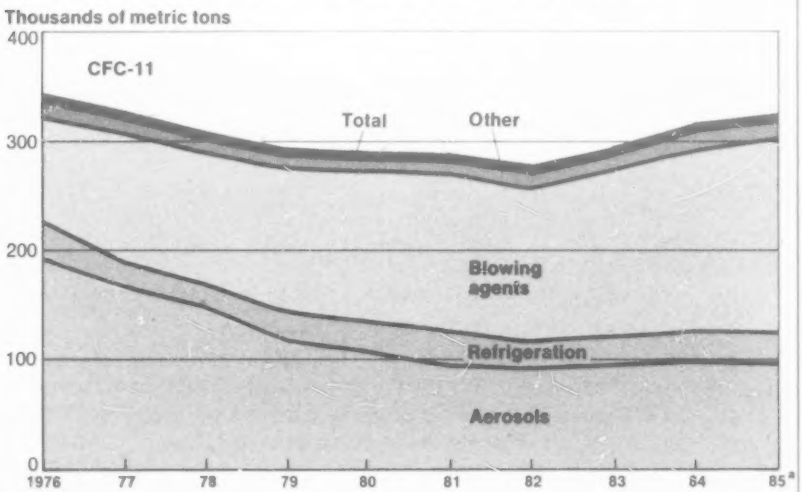
Throughout its relatively short history, the aerosol industry has proclaimed a number of virtues for the package—ease of application, protection from contamination of the product, control of doses, and so on. According to work done for the British Aerosol Manufacturers' Association by product marketers themselves, aerosols in many cases are actually a more cost-effective packaging form for the consumer than other types of packaging.

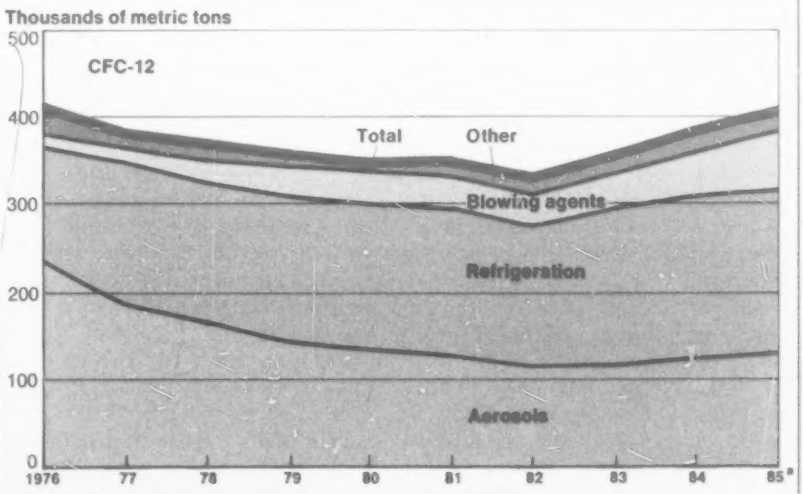
Because of those benefits, the industry saw spectacular growth in the early days. But one problem was associated with that growth—aerosols are convenience products. Con-

Worldwide production of chlorofluorocarbons is picking up again . . .



. . . but not because of use as aerosol propellants





a Estimate. **Sources:** Chemical Manufacturers Association, C&EN estimates

sumers don't really need them. So when the whole chlorofluorocarbon-ozone controversy erupted in the mid-1970s, aerosols were hard to justify, and hence were vulnerable.

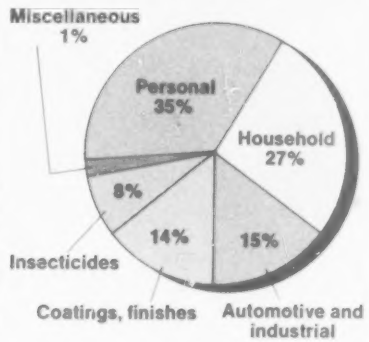
According to the theory put forward first in the early 1970s by University of California, Irvine, researchers F. Sherwood Rowland and Mario J. Molina, chlorofluorocarbons are not degraded under normal conditions, but persist to react with stratospheric ozone, breaking it down and destroying part of the ozone shield around Earth. The result is an increase in the amount of ultraviolet radiation reaching Earth's surface. The most obvious source of free chlorofluorocarbons was aerosol propellants. The way it was usually explained in the U.S. market, the consumer was faced with the choice of using an aerosol such as an underarm antiperspirant and causing depletion of the ozone layer and an increase in skin cancer, or using no aerosols and maintaining an intact ozone layer. Aerosols did not win out. Consumers believed all aerosols were contributing to air pollution, even though more than half the industry—55%—used hydrocarbons, not chlorofluorocarbons, as propellants.

In the U.S. in 1972, there were nearly 3 billion aerosol units filled; by 1975 the market was down to about 2.1 billion. It has been a long, hard slog for the U.S. market to come back to the 2.5 billion units expected to be announced by CSMA in May.

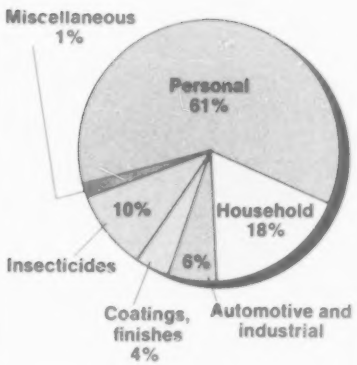
On the other hand, the aerosol industry in Western Europe used to look with awe at the massive numbers and growth in the U.S., but has long since ceased to do that. It never experienced the same pressures over chlorofluorocarbon propellants that the U.S. industry experienced, so did not suffer the same decline.

The Western European market is now quite a bit larger than that in the U.S., according to Figurama, a set of statistics published every two years by Metal Box, British packaging maker based in Reading and one of Europe's largest producers of aerosol cans. While many U.S. manufacturers and marketers were studiously avoiding innovation and

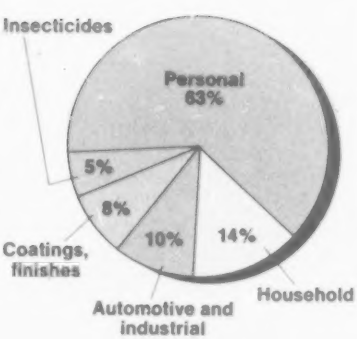
Nonfood aerosol products show different patterns



U.S. = 2.26 billion units, 1984



U.K. = 626 million units, 1984



West Germany = 604 million units, 1984

Sources: National aerosol associations in the U.S., U.K., and West Germany

new product development, Europeans went ahead. Now, new packages and new products are developed in Europe and then brought to the U.S.

One of the most spectacular cases in point is the mousse. The mousse may be, as one industry old-timer sniffs, old technology. But it came along at just the right time, with just the right products.

As Metal Box's Arthur Simpson, marketing manager for personal products and aerosols in the general packaging division, sees it, "The time was right, and also, L'Oreal got it right." On the Continent, he explains, about 90% of all hair salons are sponsored by hair-care product manufacturers, who supply chemicals and appliances. L'Oreal produced a hair-styling mousse for its salons, then received so many requests to sell it directly to its customers, that it eventually decided to do so. The foam technology was new for that market, and the product itself also featured a new resin that helped soften the keratin in hair, to give a quasi-permanent set.

From hair-styling preparations, the mousse technology is spreading into other kinds of products. For example, Elizabeth Arden has just introduced new mousse color makeup products. Other marketers are working on other lines—for example, body lotions and baby products.

Consumers in the U.S. liked the mousse products themselves and the packages as well. The cans were aluminum, imported at the time from Europe—slim, elegant, and more appealing than the chunkier tinplate cans typical in the marketplace. For the U.S., mousse products were a blessing to pull the industry out of its doldrums. As consumers bought, producers advertised more, and consumers bought even more.

Ironically, mousses have not done all that much for propellant suppliers because many of the formulations contain only about 5% propellant. Regular hair sprays, on the other hand, use much more.

Propellant suppliers, however, have benefited from the other major new product that found success in the marketplace—dry air fresheners. These have extremely high concentrations of propellant and very little solvent or oil. So they can be sprayed directly onto curtains or upholstery fabrics with little chance of causing fabric dyes to run or stain.

Dry air fresheners are an example of marketers working with researchers, notes Metal Box's Simpson. "The two have to work together. There had been complaints from consumers on the question of staining," so marketing requested a dry, nonstaining air freshener. "With hindsight, it was ever so easy to do," he says. "But when a formulation used to be 25% ethanol or white spirit of some light oil, some perfume, and so on, and now it is only about 1 to 2% perfume, and the rest propellant, that is a very different formulation."

Other market segments are also growing, but they tend to show different trends in different countries. For example, in the U.S., the market for personal-care products—particularly antiperspirants and deodorants—has always been stronger than in Western Europe. But correspondingly, the deocolognes that are a major category in Europe have not been very successful in the U.S.

In Japan, where the market is showing good growth, aerosol insecticides occupy a very high percentage of the market. The industry there has just taken a bash, however. The government has levied a new tax on the ethanol used in aerosols. And Japanese consumers have shown a fondness for alternative packages, such as pump sprays.

In Britain also, aerosol insecticides occupy a high percentage of the market. But that country, which prides itself on few mosquitoes and other similar insect pests, sends most of the aerosol products to the export market. Wellcome Foundation's Pif Paf insecticide, for example, is the leading brand in the Middle East, in particular, and is one of the major aerosol insecticides throughout the world.

All countries that produce aerosol products, however, are earnestly searching for new markets. For the British market, aerosolized foods are just becoming a significant category, following the success of aerosol whipped cream—a product that was

Methylene chloride: one lost, the rest saved?

In the aerosol industry, life has been one long struggle for propellants. First it was chlorofluorocarbons, cast under such a cloud of suspicion about possible ozone damage that they were eventually banned from all but a few exceptional uses. Now it is methylene chloride. Although at least one major aerosol end use—hair sprays—seems to have gone by the boards, others seem to be secure, albeit with increasingly strict precautionary labeling.

Aerosols accounted for 24% of the 584 million lb of methylene chloride consumed last year in the U.S. That's slightly less than methylene chloride's major use—paint strippers, which held 28% of the market—but more than twice as much as the next leading market segment, degreasers.

Methylene chloride is used primarily as a solvent for the materials being propelled. Other solvents can be—and have been—used, of course. But methylene chloride has one major advantage: It is nonflammable, and it suppresses the flammability of other chemicals in the formulation. It also functions as a vapor pressure depressant, and as a viscosity thinner.

Hair sprays have been one of the most visible aerosol markets for methylene chloride. Used at up to about 25% of the formulation, the chemical provides solutions of the film-forming resins, and depresses the cloud point of resins in both alcohol-hydrocarbon and alcohol-carbon dioxide systems. Other aerosols dependent upon methylene chloride are coatings products, some of which contain as much as 35% methylene chloride, insecticides, and a variety of other household products.

One of the major attractions of methylene chloride, then, is its safety action as a flame suppressant. So it is ironic that it has run into problems on safety grounds—in particular, carcinogenic testing. Last year, animal tests conducted by the National Toxicology Program in an inhalation study at several thousand parts per million showed several positive results. Specifically, mice tested at the exposure levels of 4000 ppm developed malignant tumors. Rats developed benign tumors in the mammary glands.

A variety of tests on a variety of animals, such as hamsters and rats, were run on methylene chloride over the years, none of which indicated a problem. At least two epidemiological studies—one by Celanese on about 1200 people, and a second by Eastman Kodak on about 1000 people—have been negative. And European marketers are optimistic about a study on the chemical there, early indications of which show no problem.

According to Paul A. Kammer, executive director of the Halogenated Solvents Industry Alliance (HSIA), Washington, D.C., the industry cannot quarrel with the results of the test by NTP. There is serious question, however, about the validity of the test results, given the exceptionally high exposure levels, and the strain of mice used in the study.

"That strain of mouse is very prone to tumors," he says. "We aren't sure what we are looking at."

HSIA, with a membership of about 150 suppliers and users of halogenated solvents, believes that a more scientifically sound approach is to study the metabolic pathways of chemicals in various species. Kammer cites studies that Imperial Chemical Industries is doing in the U.K. to trace the different routes by which methylene chloride is metabolized in various species. "One of the metabolites in mice is carcinogenic; at human inhalation rates, we don't see that metabolite. That is one reason, we think, why we don't see cancer in humans. This is changing the way people do risk assessments: People are learning so much more about how chemicals can work."

In the meantime, however, the positive study on methylene chloride has caused a great deal of distress among government regulatory agencies (C&EN, March 17, page 17).

The Food & Drug Administration has taken the swiftest, harshest action. It has proposed a ban on the use of methylene chloride in hair sprays, over which it has jurisdiction. It said it proposed the ban to protect "those facing the greatest risk from such products," an estimated 300,000 people in the U.S. employed as licensed hair-care specialists, who use hair sprays in their work. To a lesser extent, there could be health hazards for the millions of people who regularly use aerosol sprays that contain methylene chloride on their own hair, FDA added. (On the other hand, it is trying to avoid banning methylene chloride as a decaffeinating agent for coffee, on the grounds that the risk would be so small as to be trivial.)

The other U.S. agency with jurisdiction over methylene chloride in aerosols is the Consumer Product Safety Commission. The commission has particular jurisdiction over insecticides, automotive and coatings products, and other household products. CPSC at first considered restrictions on the use of methylene chloride in aerosols. But now, reports HSIA's Kammer, "I'm getting optimistic about methylene chloride. Nobody at CPSC is talking about a ban any more. They know the data aren't there to back it up. The action will be for improved labeling—for adequate ventilation, for example, and for point of purchase pamphlets on how to use the products properly. I think they will buy it," as an alternative to a ban.

That doesn't necessarily displease Kammer. After all, he says, methylene chloride is one of the safest products around—but people need to use it safely.

launched and buried once before 10 years ago.

In the U.S., aerosol pharmaceutical products are becoming a hot topic in the R&D labs, industry observers report. Mousse technology, for example, could be used to produce edible whipped foams—perhaps just the thing to serve up medicine in, to a recalcitrant child. The pharmaceutical industry, says one supplier, is finally beginning to understand the benefits of aerosols. They make the package less accessible to children, there is no air inside to contaminate the product, and they are nonspilling and easy to dispense.

Moreover, the development of aerosol forms of an existing pharmaceutical can be one way for drug companies to extend the patent life

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In a sense, the aerosol industry has become accustomed to the controversy about chlorofluorocarbons. It is an ongoing debate that has become part of the industry, for better or worse. But other threats aimed at the industry are more immediate and more worrisome. Some industry observers are concerned that eventually these threats will take on the same weight and magnitude that the ozone-chlorofluorocarbon issue had.

The major concern for U.S. producers is smog and how hydrocarbon propellants contribute or do not contribute to its formation. The California Air Resources Board has begun to consider legislation to control the use of hydrocarbon propellants in aerosols, as part of its efforts to control hydrocarbon emissions and smog formation.

As early as September 1982, members of CSMA, the major aerosols trade group, testified at hearings before California's Bay Area Air Quality Management District board of directors, to contest such action. In the CSMA testimony, given by Roger Beutner, vice president of manufacturing for Amway Corp., the association argued that those who favored the proposed ban overestimated the current emissions from aerosol hydrocarbons; thus, it would not accomplish what they hoped. Moreover, the association said that the measure would not be cost-effective. CSMA claimed that it would have a negative economic impact on the industry at least 60 times greater than estimated and that it unfairly discriminated against aerosols vs. other nonaerosol products.

Since 1982 the issue has not died, however. If anything, pressures have become stronger. California is concerned, of course, not just about aerosols; it is also tightening controls on emissions from automobiles, from paints and coatings, and so on.

But aerosols are a convenient target to control. For example, California authorities figure that because

there are alternatives to aerosols for such applications as hair sprays and antiperspirants—for instance, pumps and roll-ons—consumers can do without aerosols. Other categories, such as aerosol paints and insecticides, are also being investigated. Notes one marketer: "This may eventually come to equal the magnitude of ozone—we don't know yet."

If California were isolated, the controversy might not be all that bad. But California's actions tend to ripple outward, so they eventually could affect the industry across the U.S.

That is the air-pollution front. The industry is also fighting smaller battles around the country on such grounds as storage of filled aerosol stocks and "antisniffing" legislation in Texas, in particular. (Sniffing refers to the practice of sniffing some aerosols to produce a "high.")

But it may give U.S. producers some comfort to know that their situation is shared by their international colleagues. For example, the issue of storage is the U.K.'s cause célèbre at the moment, reports David Roberts, director of BAMA. He relates a saga that begins with the formulation, by the British Health & Safety Executive (HSE), of a program for notification concerning installations handling hazardous substances. HSE decided that facilities with more than a specified number of tons of particular chemicals would have to notify the agency. The program was developed as part of regulations to isolate those chemicals that could be involved in major industrial accidents.

"The level for butane was 25 tons," recalls Roberts, "and we advised our members that it would affect bulk stocks only. We were horrified when HSE decided that it would also affect butane in packaged stocks. That brings in people with less than 25 tons of bulk stocks but with commercial warehouses. If you are, for example, Sainsbury's [a major British supermarket chain] with a central warehouse, you would have to go to each supplier and ask, 'How much hydrocarbon is used per can?' You would have to compile figures and compute if you are over or under."

BAMA met with HSE, and, ac-

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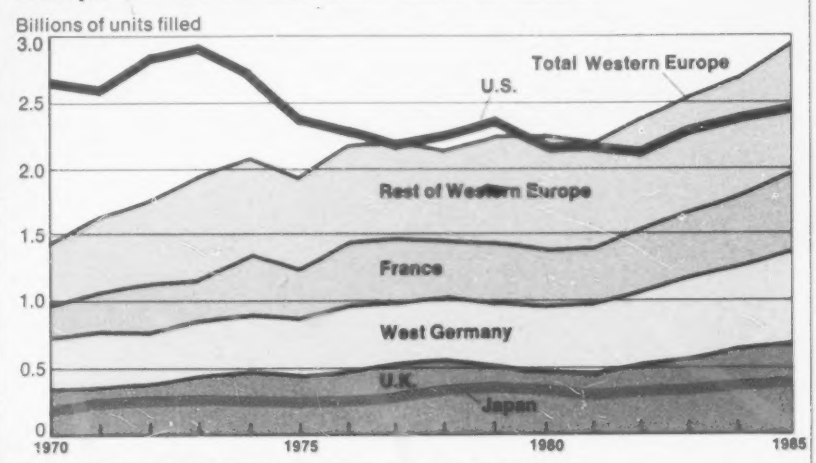
Europe is now the dominant aerosol market



Sources: Metal Box, British Aerosol Manufacturers' Association, C&EN estimates

cording to Roberts, was told that the group should prepare a case, and HSE would work out an exemption. A draft report went back and forth several times. It was eventually submitted to HSE, which held the submission for three months, then turned it down and said, "Everybody's got to notify in three days."

The group decided to appeal on the grounds, basically, of proportional risk. "Yes, an aerosol warehouse will burn nicely," concedes Roberts. "But this isn't Seveso." BAMA went to judicial review, where HSE argued that the ruling wasn't a "directive," merely an "advise." "They sought on a technicality not to get a ruling; they didn't want the rule to be clarified," says Roberts. "We've written to our members that we don't think this applies to packed aerosols, so ignore it. So it is now back in HSE's court."

Other draft regulations in Britain apply to building regulations, with notices for fire brigades if more than 25 tons of dangerous goods (including flammable aerosols) is aggregated.

European Economic Community regulations have led to the formation of rules to follow for accident plans. In the case of aerosols, if more than 200 tons of butane is stored, a company must have an accident plan, inform neighbors, staff, and so on. However, various countries are interpreting the rules in different ways. Many are applying them only to bulk stocks, not to stocks of packed aerosols.

One of the results of the U.S. industry's facing so many battlefronts is the formation, within the past year, of a new industry group, the National Aerosol Association. The major force behind the group is Aeropres' president Sam Copia, one of the founders. He reacts angrily when told of what he feels are misconceptions by U.S. industry and trade media alike that the group was formed as a competitive trade group to CSMA.

"Anything that promotes aerosols won't rival any other organization that promotes them," he argues. According to other sources, the main aim of the group is to educate the general public about aerosols. The original founders thought, they say, that CSMA had become too absorbed in fighting the battles of methylene chloride and California's air emissions standards to publicize the positive aspects of aerosols. And many in the industry believe that promoting the positive features of the aerosol package is what has been sorely needed for a number of years.

As mentioned earlier, for the U.S. aerosol industry, the controversy over chlorofluorocarbons gave only the final push to a switch to hydrocarbons that had begun years earlier. At the time of the controversy, hydrocarbons already were being used in some 55% of all aerosols filled because they were less expensive than fluorocarbons. When

the Environmental Protection Agency eventually banned chlorofluorocarbon propellants, however, most of the rest of the industry switched over. Only a very few exemptions, such as pharmaceutical aerosols, were permitted.

It was a traumatic time. The industry was suddenly faced with the need for massive capital investment in new filling equipment. Marketers were faced with an abrupt need for reformulating. And consumers took some time getting used to what were different products with slightly different characteristics.

As a result, sales slumped a third. Marketers were quick to drop chlorofluorocarbons, and, rather than attempt to educate the public on the differences between the two kinds of propellants, some dropped aerosols altogether. Alternative product forms abounded—pump sprays for hair spray and window cleaners, and stick and roll-on forms of antiperspirants and deodorants.

Sales are slowly working their way back. But for an industry that once reveled in growth rates of 8 to 10% per year, 2 to 4% is excruciatingly slow. As seen through European eyes, "The U.S. is still suffering," Metal Box's Simpson observes. "In the mid-1970s, the markets moved away from aerosols because of the 'pollutant' taint. Scientists are still arguing, and they are no further forward."

The shift, however, has left hydrocarbons the mainstay of the aerosol industry. The major suppliers are Phillips 66 Co., Bartlesville, Okla.; Diversified Chemicals & Propellants, Chicago; and Aeropres Corp. Aeropres bills itself as the largest supplier to the aerosol industry, particularly with the boost to its business it received when it purchased Industrial Hydrocarbon's capacity several years ago.

Though growth is slow, it is growth, and some suppliers can even report that business has been excellent. Growth has been very modest over the past two years, points out Richard Frauenheim, president of Diversified. "But it is good to be going back up."

Given the abrupt shift the U.S. industry went through and its aftermath of market decline, European suppliers have tried to hedge their bets for all possibilities, no matter how unlikely or unwelcome. Notes Roberts of BAMA, large fillers in the U.K. have put in hydrocarbon facilities. This gives fillers the opportunity for total substitution if needed. But blending with chlorofluorocarbons has been the favored route to meet the 30% reduction in chlorofluorocarbons required by EEC. They prepared, adds one supplier, for a "worst-case" situation: being forced to abandon chlorofluorocarbons. If an abrupt switchover were required, they would have to invest more rapidly than usual. This way, the investment already has been made at a

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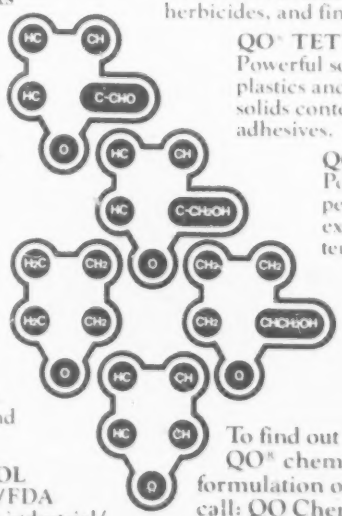

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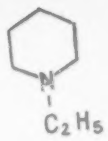
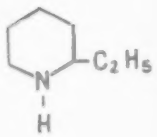
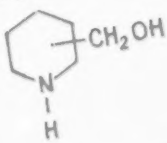


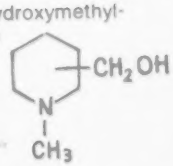
2-Ethyl-piperidine



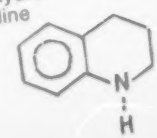
Hydroxymethyl-piperidine



N-Methyl- hydroxymethyl-piperidine



1, 2, 3, 4-Tetrahydro-quinoline



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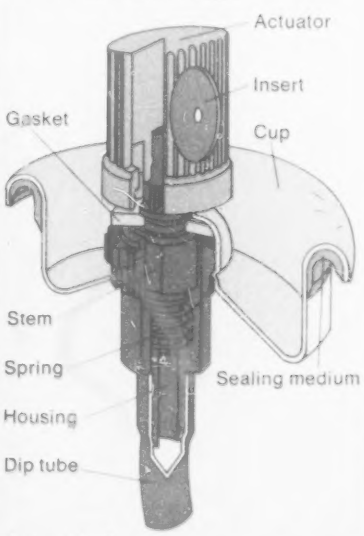
more controllable pace. All major fillers in the U.K. can use hydrocarbons, but most use mixtures, not pure hydrocarbons.

European marketers and consumers, suppliers contend, find that the substitute propellants give less acceptable products. They worry about consumer hazards, with flammability. But most of all, marketers worry that if they continue to reduce their use of chlorofluorocarbons, consumers will turn away from aerosols altogether. They fear that their sales will drop off just as dramatically as the U.S. aerosol sales did in the mid-1970s.

"On purely economic grounds, there are merits in using hydrocarbons. But chemists say the formulations don't have all the properties of those with chlorofluorocarbons," says Metal Box's Simpson. "The U.S. government used consultants to indicate how much money would be saved by switching to hydrocarbons—but the industry went down by one third."

With that kind of resistance, it will take some selling to open the hydrocarbons market in Europe. That's a challenge Diversified's Frauenheim is willing to take on, however, to share in the European industry's growth. The company is building a plant in Krefeld, West Germany, just outside Düsseldorf,

Aerosol mechanism: a lot in a little package



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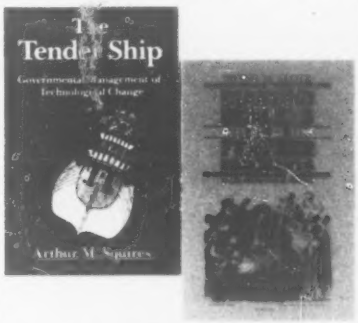

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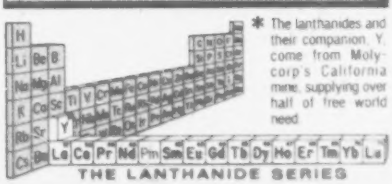

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for producing hydrocarbon propellants. "We also will be marketing fluorocarbon propellants and some foam-blowing agents," says Frauenheim. The plant is under construction and will be operational by this fall.

"I don't think it will be difficult selling hydrocarbons in Europe," he contends. "It's our opinion that companies in Europe are experiencing the same thing U.S. companies did in the 1970s. They are being told by fluorocarbon marketers that hydrocarbon propellants are not of proper quality. We have managed to convince them here that that is not true. Once they've changed, some products are even better. We have the background and experience, and with our technology, products will be even better than they are now."

Some European industry executives would argue that that is a U.S. view of the situation. In Europe the industry has used butane in household products since the 1960s. And it has made extensive use of propellant blends.

Nonetheless, other suppliers continue to work on new propellants and propellant blends. A case in point is Du Pont, who is touting dimethyl ether propellant to the aerosol industry. The company has been selling commercial quantities of the propellant since 1982, but has found market penetration slow in the sluggishly growing business.

But Du Pont's Don Dunn, sales manager for its Dymel line of aerosol propellants, reports that business has begun looking healthier over the past year. Dimethyl ether and other specialty propellants are potential replacements for methylene chloride and can be used to make water-based, nonflammable systems, he believes. They also reduce the flammability of solvents and of systems with high concentrations of propellants. "Companies are trying to look at other technologies, other chemistry, to have options just in case the government forces them to move. They want something to move to," he says.

"When we introduced our products three or four years ago," Dunn says, "they were new, and we were trying to convince people to switch. That's always difficult for products that generally cost more. Now we are through that stage. New products are coming in for which their manufacturers have considered all the options. We are in at the base-building point." That can be a long, time-consuming process, he points out—several years to develop a new product, test the propellants and solvents in a formulation, determine how the product ingredients react with them, test for any reaction with the container or container lining. "It actually is very difficult for a marketer to get a new product out because so much is at risk."

There is also some interest in these new propellants among European marketers, particularly of fragrances, who want to export directly into the U.S. and into European countries that restrict chlorofluorocarbon use without changing propellant and formulation. The new propellants can be used to meet any regulations anywhere, allowing a one-time-only multinational formulation (C&EN, April 29, 1985, page 19).

Changing formulations and making product innovations may be one way for the industry to bring about its own revitalization. Things are picking up in the marketplace. In Western Europe, sales are sparkling. British aerosol manufacturers are gratified with 11% growth in 1985. On the Continent, sales are expected to approach double-digit rates. Even in the U.S., with the slow growth that industry has seen over the past several years, the situation may be improving. It is possible to detect hints of enthusiasm that were missing during the industry's beleaguered years. Key to the revival are new or better products—not necessarily those put into aerosols, but the aerosol components products are put into.

Industry veteran and valve consultant Walter C. Beard, for example, says he is "more excited about the industry now than when I started 35 years ago." The reasons for his enthusiasm are the new valves he has invented and licensed to Bespak, British manufacturer of specialty valves, for marketing in Europe. He is also negotiating with Bespak a license for marketing the valves in the U.S.—Bespak is build-

ing a new plant in North Carolina—and in the rest of the world.

A number of valves are involved: special metering valves to work with any pressurized system; high-flow valves for viscous materials and beverages; specialty protective valves through which air cannot get at the contents of the package. These valves are particularly good for protecting moisture-sensitive products. Beard, based in Middlebury, Conn., is also working on a series of valves especially for plastic containers, which he thinks have a bright future in the aerosol industry. "There is a lot going on here and in Europe with plastic containers," he notes.

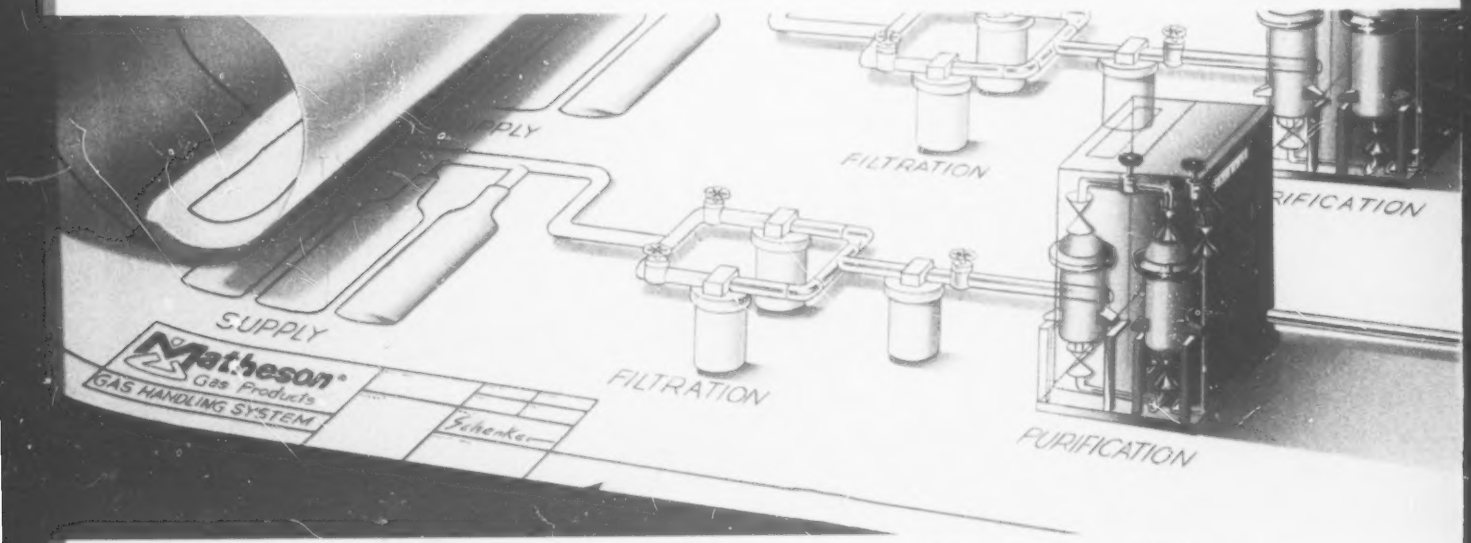
That's the kind of belief in new packaging that pleases Wheaton Industries, Mays Landing, N.J., which has launched a new aerosol container made of polyethylene terephthalate (PET). Plastic containers are not a new idea: Celcon acetal copolymer was highly touted in the 1970s, but went nowhere commercially. It and polycarbonate were very expensive, says Bob Shiels, executive vice president and general manager of Wheaton Aerosols. "We had hoped that, at some time, they would be feasible because the resin price would drop. But the prices never did. Also, Celcon never did do a lot of what we needed to do. It was a bit brittle and needed to have thick walls to get the barrier properties."

PET, on the other hand, is a good barrier, Shiels explains, especially for carbon dioxide. This is the reason it has been adopted by the beverage industry. Drawing from Wheaton's experience in the industry, Shiels says, "We learned a lot. PET is a good, stable resin, easier to work with, and do more with, than Celcon. We thought we saw a problem with crystallinity, but it looks now as though that is not a problem." Customers will have to test their formulations in the new package, he notes, but that's a standard pre-

Newest U.K. figures show encouraging growth

Millions of units	1984	1985	% change
Hair care products	140	182	30%
Personal deodorants, deocolognes, antiperspirants	104	115	11
Medicinals, pharmaceuticals	66.5	69	4
Insecticides	64.5	63	−2
Waxes, polishes	52	50	−4
Air fresheners	40	45	12
Colognes, perfumes	42	41	−2
Paints, lacquers	22	24.5	11
Automotive products	23	24	4
Shaving lather	20.5	23	12
Industrial products	12	13	8
Starches, fabric finishes	9	10.5	16
Miscellaneous	12.5	19	52
TOTAL	608	679	11%

Source: British Aerosol Manufacturers' Association



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caution whenever a new package is adopted.

Wheaton's specialty in the industry is glass bottles. So despite what some metal-can producers think—that PET will be limited to small, specialty packages, much as glass is now—PET is "definitely a replacement for cans," according to Shiels. "Glass is vulnerable for some uses, especially where there might be breakage problems. But not really, in the fine end of the cosmetics and toiletries business. Do people want plastics for those products? For a high-priced fragrance, glass has an ambience all its own," he adds, explaining why he won't set the two in competition.

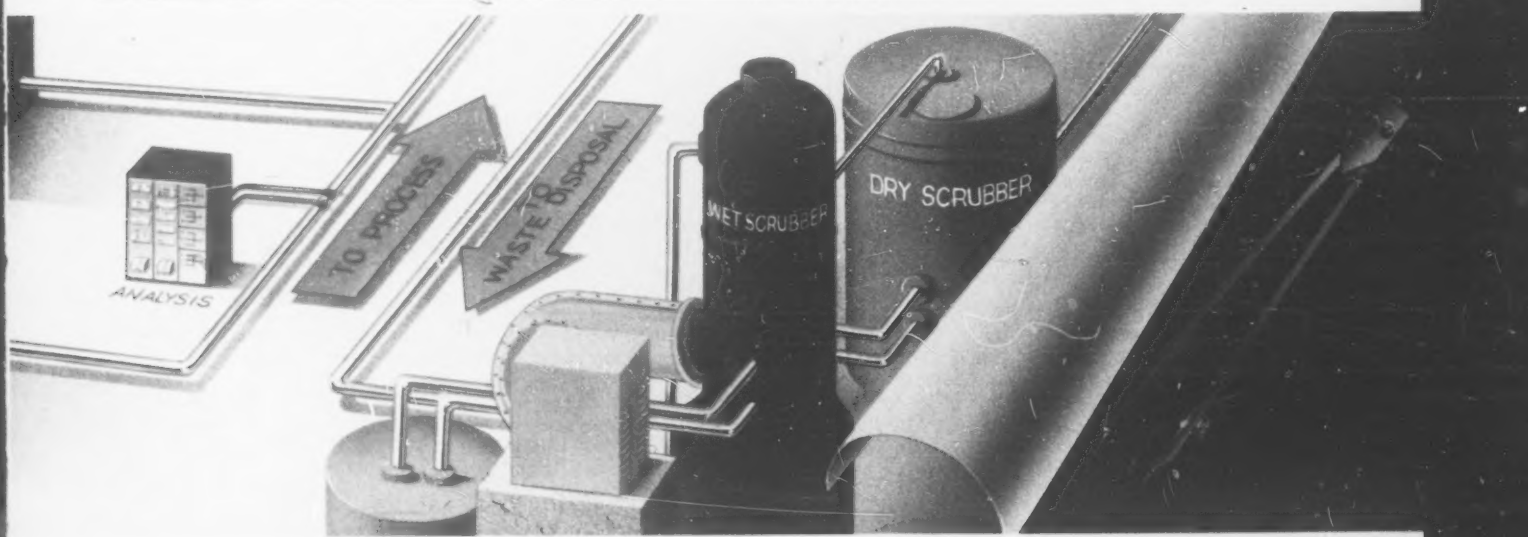
He is aiming to use PET containers as a substitute for metal cans. He claims that PET containers have weight advantages and can be made in different transparencies from completely transparent through translucent to opaque "in all colors of the rainbow." Also, they do not corrode and therefore require no interior linings. And because the container is blow-molded, various surface effects can be molded in, such as hobnailing or diamond patterns. Currently, the economics of PET containers are roughly those of aluminum cans, or perhaps even a little poorer. "But even if PET containers are the same price, and you can get rid of problems, they are worth it."

One of the problems, as many suppliers see it, is that there is a shortage of people actually familiar with aerosols and aerosol technology in product design. That is true particularly in relatively untapped areas such as the pharmaceutical industry. Only a few universities have strength in teaching aerosol technology. Long Island University in New York has courses and seminars on aerosol technology, under the guidance of former dean John Sciarra, who is a consultant in the industry and a frequent contributor to the specialty trade magazine *Aerosol Age*. And in the U.K., the University of Sussex in Brighton offers a degree in pharmacy that includes a one-year course on aerosols.

Those formal programs are rare, however. Far more commonly, people learn the business through their on-the-job experience. "It's quite a crazy situation," complains Metal Box's Simpson. "There just are not enough people with the vision to know what you can do."

That's not to say the industry sits around doing nothing. But the research and development that is done often seems to be accomplished in fits and starts. In the U.S., much of it has been purely defensive over the past decade, consisting of attempts to defend the market that existed, rather than design for new markets.

One of the fits and starts deals with can production—specifically, welding the seam down the sides



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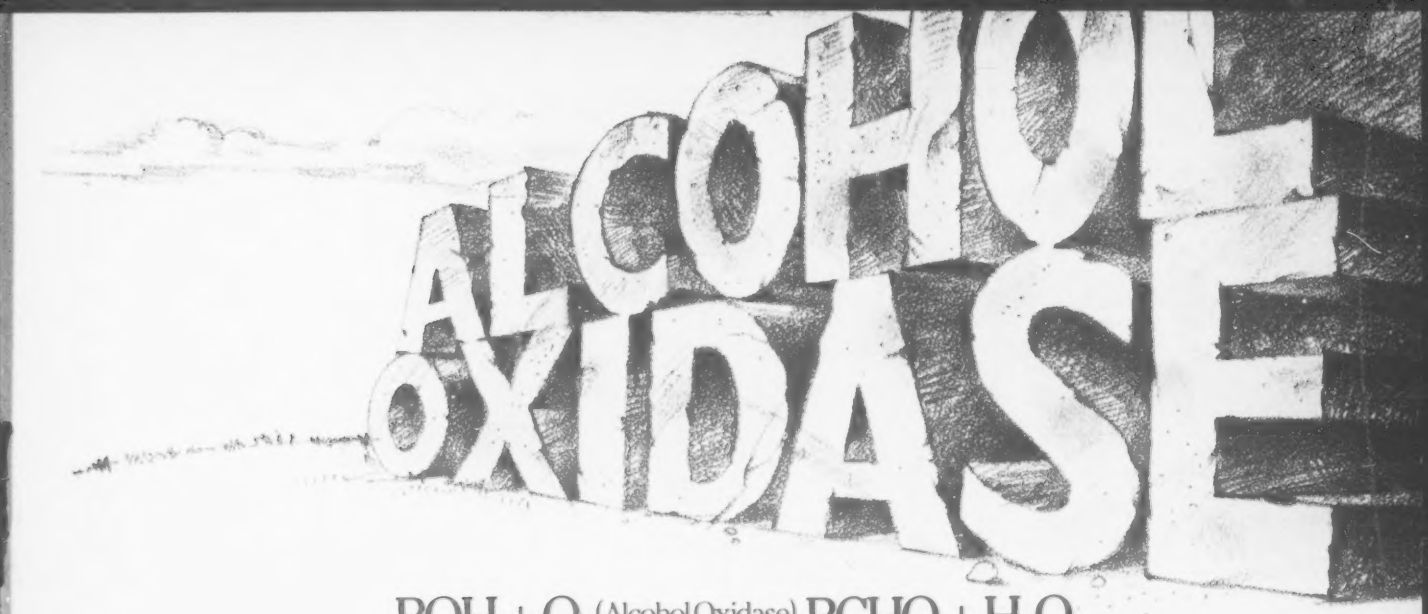

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on tinplate cans. For example, some research has been done on laser welding of the cans, which would eliminate even the thin seam that now shows.

But primarily because of the competition between tinplate and aluminum cans, more work has been done on improving the existing package designs. For years one aerosol can looked much the same as any other aerosol can. However, the situation in the U.S. differed somewhat from that in Western Europe.

Historically, the U.S. industry has used tinplate, with some glass as specialty packaging. But in Western Europe, the first aerosol cans were aluminum. The U.K. had built tinplate capacity by 1953, whereas in West Germany, soldered tinplate was not really available for aerosols until the late 1950s. By that time, aluminum had a firm grip on the European market. In West Germany, aluminum now holds 55% of the aerosol container business, compared with 40% for tinplate and 5% for glass. In the U.K., tinplate accounts for 75% of the market, aluminum 15%, and glass 10%, says Metal Box's Simpson.

It was the aluminum can used by European designers that was responsible for a great deal of the success of the mousse products that rejuvenated the aerosol industry, both in Western Europe and the U.S. The aluminum cans, marketers feel, have more of an "up-market" image than the old tinplate and are more aesthetically appealing to the consumer.

Contends one marketer, for example, "In Europe, aerosols have moved out of the commodity business. They now look nice. Even the products for use with a car are nicely presented. In the U.S., aerosols have been very much a commodity item—they have looked scruffy. They aren't sold as something desirable. They are sold as something needed. Therefore, the price marketers could get for the product was just a little bit less. It may be just a matter of pennies, but it makes all the difference to the bottom line."

Suppliers of chlorofluorocarbon propellants at Imperial Chemical Industries would agree with that. Says Stuart Kelly, whose team compiles filling statistics from Western Europe and the U.S., "We originally started these papers with the thought that the U.S. was the pointer to what would happen in Europe. The situation has completely turned around: Now the technological innovations and marketing initiatives are Europe-led. They are very much picked up and copied by the U.S."

The elegant aluminum cans from Europe have spurred the tinplate-can makers into brushing up their own act by refining their products. The most recent major development to be commercially successful for tinplate is the "necked-in" can, which features a can neck that is taper[illegible] just a bit, so that when the cap is put on, it makes a smooth line from top to bottom. There is no ridge where cap meets can.

According to Simpson, Metal Box now produces six of its necked-in Trimline for every one regular can. "Over 90% of our cans are Trimline.

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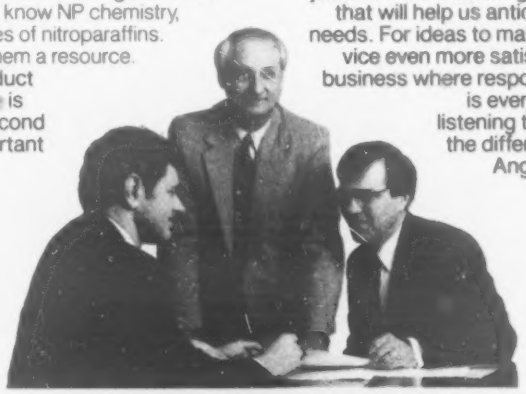

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We've gone almost completely to that, even though there is no difference in price. The cans just look better."

The new designs also have a coincidental advantage that appeals to marketers. The elimination of that minute ridge around the can means that distributors can get up to 10% more product on a truck.

Also, the new cans can be made in smaller sizes. This is important for keeping up with the current down-sizing trend in Europe. Says Simpson: "We are using proportionally more capital for the smaller cans, but they have got the marketer into product sectors he hadn't been in before—small cans for handbags, for example, or for suntan products—where people don't want really big cans."

Tinplate cans sell primarily because of cost advantages. They are 10 to 25% cheaper than aluminum cans. Also, tinplate-can manufacturers claim that printing is superior on tinplate. "The printing is better because you are actually printing on the flat. With aluminum, you have to print on the round," explains Simpson.

However, just as competition from the aluminum-can makers have forced tinplate-can manufacturers to sharpen their own capabilities, the graphics on aluminum have improved because of competition from tinplate. "They're doing much better than they were; they can do six- or seven-color printing now," Simpson notes.

The result is that new technology is moving to the U.S., where can makers see a better package. "It may still not sell them more cans, but it will prevent aluminum from continuing its inroads," Simpson says. "It's exactly the same situation we had in Europe. The marketers had a choice, so we the tinplate makers had to make better packages."

U.S. aerosol can production has been dominated by the can companies—National Can and Continental Can, in particular—and Crown Cork & Seal. Metal Box is the major supplier outside the U.S., selling from its U.K.-based headquarters to some 60 countries. It has sold to the U.S. for about three years. When mousses were first introduced in

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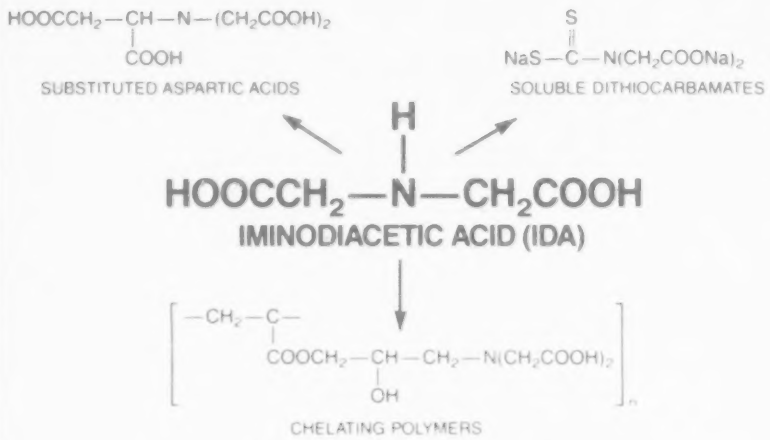

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their aluminum containers, all the aluminum cans were being imported. Since then, however, a number of aluminum-can production lines have been built by U.S., Canadian, and European producers. France's Boxal, for example, has built three production lines, and others have added to what probably is now overcapacity.

"Nobody is at capacity. There will be as many aluminum cans as you want, in the foreseeable future," says one observer. "The mousse market has stabilized, and some [companies]—L'Oreal, for one—are still importing cans. There is no trend toward pretty aluminum just because of aesthetics." On the other hand, he adds, "I haven't heard of any price cuts," so things cannot be too bad.

Overcapacity but no price cuts—these are just two indications of an industry, particularly in the U.S., that is getting back to normal after a breathless several years scrambling to fill demand for containers and filling capacity. The European scene is already well supplied, and the U.S. is quickly becoming so. And the players are no longer strictly national companies.

Instead, suppliers are becoming increasingly international to better serve their customers, the international marketers. Aerosol plants will become bigger and more consolidated. Can production in Ontario may serve the U.S. or Taiwan; production in the U.K. may go to Egypt or Kenya; production in France to New York. Fillers will find their products going farther afield—a U.S. marketer filling products there for a destination in other parts of the world, for example, or a French marketer filling in France, then sending product to the U.S.

In other words, innovative and styling trends may have ceased to be dominated by the U.S., and the business itself is moving away from a one-country look. Global marketing is the buzzword phrase these days, and the industries that put their products into aerosols are no exception. Their business is becoming more international. That internationalization is good news for the aerosol industry as it marches back into good health. □

Survey data probe status of chemists

The chemical profession in the U.S. is dominated by white males. In 1985, more than three fourths of the members of the American Chemical Society fit that description.

Consequently, any broad demographic look at working chemists is likely to be skewed to reflect the characteristics of that single dominant mass, one in which the traits of all the many smaller groups, such as Asians or blacks—or even women—may be largely buried.

Last year's annual survey of employment and salaries among members of ACS, however, has provided an unprecedented opportunity to gauge the economic status of groups of chemists who are too few in number to have been represented adequately in earlier surveys.

The 1985 ACS survey differed from previous surveys in that it targeted all members living in the U.S. who were under 70 years of age and neither retired nor students, rather than just a random sampling of such members. Response to the survey was about 50%, so that data were obtained from nearly 44,000 members, three to four times more than responded to other recent surveys. As a result, usable information is available for the first time from several groups of chemists from whom responses previously had been relatively sparse.

In addition, the more detailed information than usual that has been garnered from the 1985 survey regarding the status of women chemists can be compared with results from two earlier surveys, in 1975 and 1980, that covered all female ACS members in the U.S. work force.

Speakers at the Division of Professional Relations' symposium on the "Status of the Chemist in 1985" evaluated this wealth of new information. So also does the report "Women Chemists 1985" just published by the ACS Office of Statistical Services.

Data compiled in "Women Chemists 1985" show that women comprise an increasingly larger fraction of the total chemical profession. Last year, about 15% of ACS members working in the U.S. were women, up from 10% in 1980 and less than 8% in 1975.

Women chemists tend to be markedly younger (and consequently less experienced) than their male colleagues, the report also shows. This is due, in large part, to the increasing share of degrees in chemistry that is being earned by women, especially at the B.S. level. Recently, a third of B.S. chemistry degrees awarded in the U.S. went to women, compared with less than 20% 15 to 20 years ago. One result is that half of women chemists whose highest degree is a B.S. are under 30 years old, but only 21% of the men with a B.S. are that young.

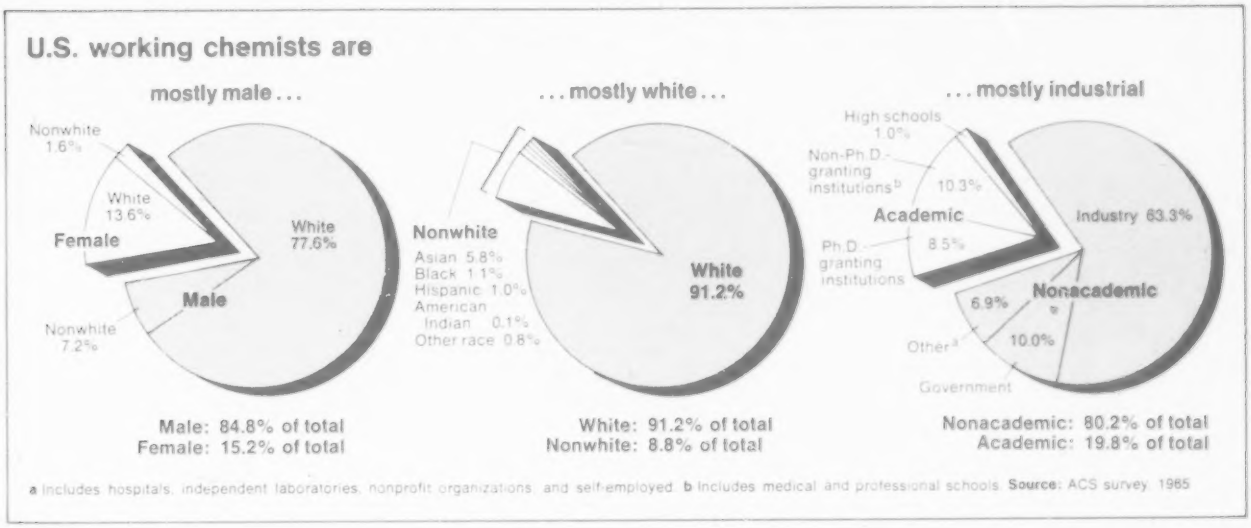
In general, the differences in salaries earned by men and women chemists working in industry or government have narrowed during the past decade, especially for young workers. Even so, men still hold an overall advantage. One reason is that women, perhaps as a reflection of their relative youth, are less apt to hold management positions. For instance, although only 16% of the men with Ph.D.s working in industry have no subordinate, 45% of the women have none.

Another factor is the areas in which women tend to work. As Polly Phipps of the University of Michigan pointed out during the Division of Professional Relations symposium, although an increasing number of women are now being attracted to chemical careers, they tend to move into fields where salaries are lowest. The two highest-paying fields of specialization for chemists are physical and polymer chemistry, for example; in both of these women are underrepresented. On the other hand, in biochemistry, pharmaceutical chemistry, and analytical chemistry, which are among the lowest-paying specialties, women are overrepresented. Similarly, salaries tend to be highest for chemists employed by oil, chemical, paper, or rubber firms, industries in which women also are underrepresented. And they tend to be low for chemists working for hospitals and independent labs or for state and local government agencies, for which the number of women employed is greater than average.

Although the percentage has been declining, women chemists with a Ph.D. are more likely to be working in universities and colleges than anywhere else. Last year, 46% of Ph.D. women worked for such institutions, compared with 34% of men with Ph.D.s. The salaries of women in academia have increased during the past 10 years relative to the salaries earned by their male counterparts, according to Margaret A. Cavanaugh of Saint Mary's College in Notre Dame, Ind. Cavanaugh finds, nonetheless, that women's salaries still slightly lag those of men in schools that do not have Ph.D. programs. And in the more prestigious institutions that award the Ph.D., the differences between men's and women's salaries can be greater still.

The 1985 ACS survey asked several questions to probe how well chemists like their work and how they view their career prospects. Generally speaking, Terrence R. Russell of the ACS Department of Professional Services finds, younger women are more satisfied with their jobs than older women are; however, the reverse is true for men. Russell hypothesizes that this is the case because younger people are more likely to compare themselves with people of similar age and sex in other professions rather than with other chemists. Thus, young women chemists tend to compare their salaries with young women in such low-paying professions as teaching or nursing, whereas young men chemists match their earnings against the income of young doctors or lawyers.

Black chemists are another group for which job conditions seem to have improved. Slightly more than 1% of native-born U.S. chemists are



black, the ACS survey indicated, in an overall U.S. population that is 12% black. They are much more likely to be women (27% are of that sex) than is the case with whites. On the other hand, their age distribution is very similar to that of whites. This suggests to sociologists Jerry Gaston of Texas A&M University and Willie Pearson Jr. of Wake Forest University that recruitment of blacks into chemistry, relative to whites, has not increased in recent years.

In analyzing salary data for black and white chemists, Gaston and Pearson conclude that at least among younger chemists the "disparity between blacks and whites has been reduced almost to the point of equality." That is, for blacks and whites of the same sex, the percentage earning above or below the average level is nearly the same if they have earned their B.S. degree in the past 20 years. This indicates considerable progress, Gaston and Pearson say, if the data are compared with those for chemists who obtained their B.S. in 1955 or before, a group in which most of the above-average salaries go to white males.

Accounting for almost 6% of ACS members working in the U.S., chemists of Asian background constitute the second largest ethnic group by a wide margin. The proportion of Asians in the chemical profession is roughly half again as big as it was 10 years ago, and it is much higher than 1.6% of the total U.S. population that was Asian at the time of the 1980 census.

A perhaps surprising 84% of Asian chemists are immigrants, according to statistics worked up by Robert Jones and Sovan Tun of the ACS statistical services office. But just over half of the total are naturalized U.S. citizens now, and another fourth, although noncitizens, hold permanent resident status. Japanese chemists, who account for 12% of all Asians, are the only exception; almost 75% of them are natives of the U.S. In contrast, of the 45% of Asian chemists who are Chinese, only 13% were born in the U.S., and practically all the Indian chemists (22% of the Asian total) were born in India.

Perhaps because, as immigrants, they need an advanced degree to compete in a foreign job market, a surprising number of Asian chemists in the U.S. have Ph.D.s. For instance, 83% of those from India and about 75% of Chinese and Korean chemists have earned a doctorate, compared to only slightly more than half of white chemists.

Chemists doing part-time work are another relatively small part of ACS membership—just over 2% of the total—but they make up a group whose characteristics are quite distinct, as well. Although more men than women work part time, the proportion of all women chemists with part-time jobs is much higher (5% compared with less than 2% among men). Thus a woman is twice as likely as a man to be working less than full time. These women, moreover, most likely hold academic jobs. According to Kathleen Trahanovsky of Iowa State University, 9% of the women employed in academic institutions work part time, and although women hold only 16% of all academic positions in chemistry, they account for 52% of all academic chemists who work part time.

Part-time chemists working outside academia tend to be older than those in full-time jobs; more than 30% are over 60, compared with less than 10% of all nonacademic chemists. They also are likely to be self-employed—18% are, compared with just 1% of all nonacademic chemists—and to be doing consulting (27%, compared with only 2% of all nonacademic chemists).

Nearly 40% of the men working part time do so because they prefer to, Trahanovsky finds; another third work part time because they have been unable to find full-time jobs. For women, on the other hand, the biggest reason for part-time work—cited by about a third—is marriage or family constraints. Only 60% of all women chemist surveyed last year were married, but of those employed part time, 83% were married.

As a sidelight, the 1985 ACS survey found that among the 60% of presently married women chemists, 30% are married to another chemist and nearly as many to some other type of scientist. On the other hand, of the 83% of surveyed men chemists who are married, only 20% are married to a scientist of any type and slightly less than half of these are married to a chemist. □